

# Merging remote sensing and models to improve performance and accessibility of snow information

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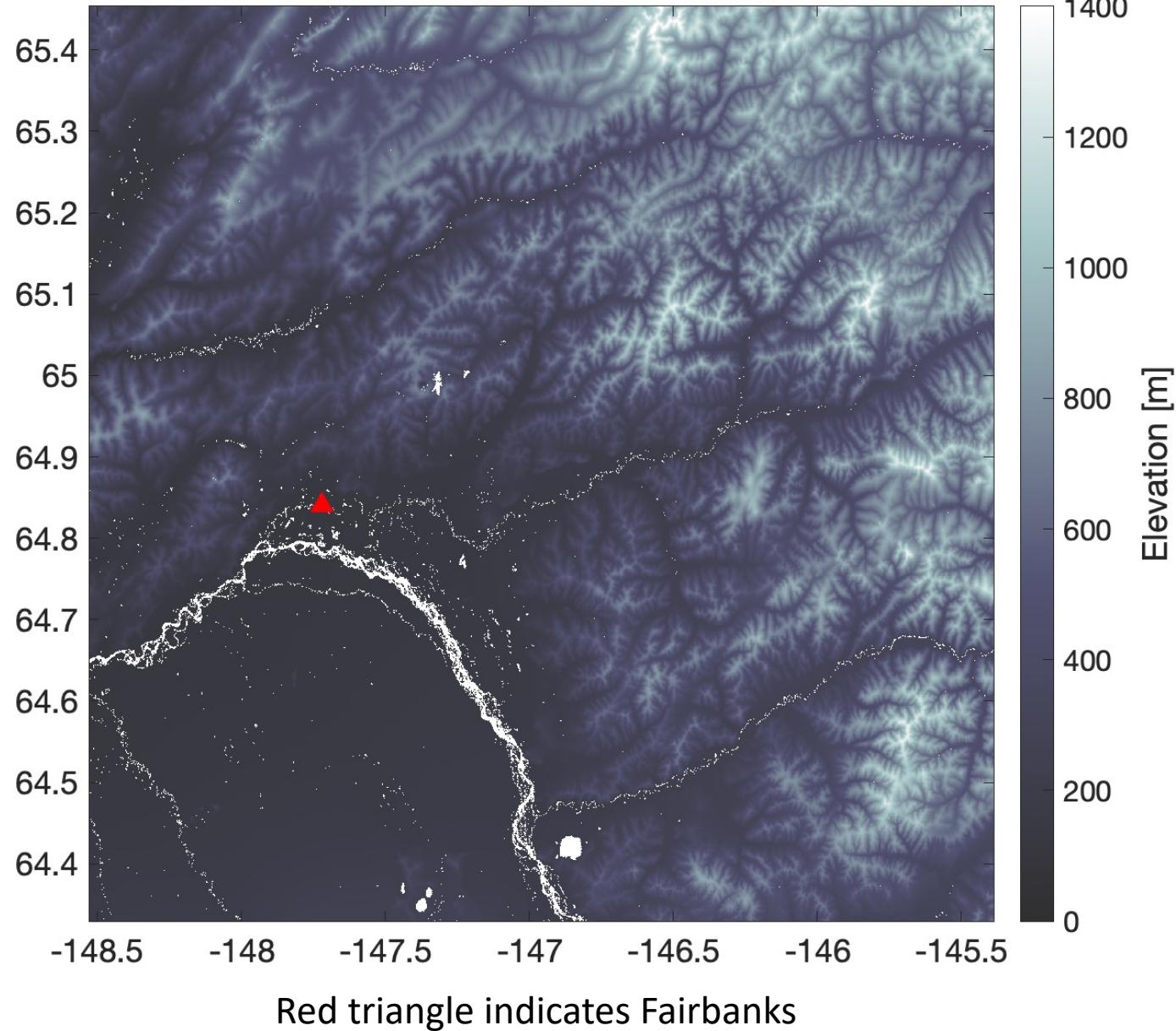
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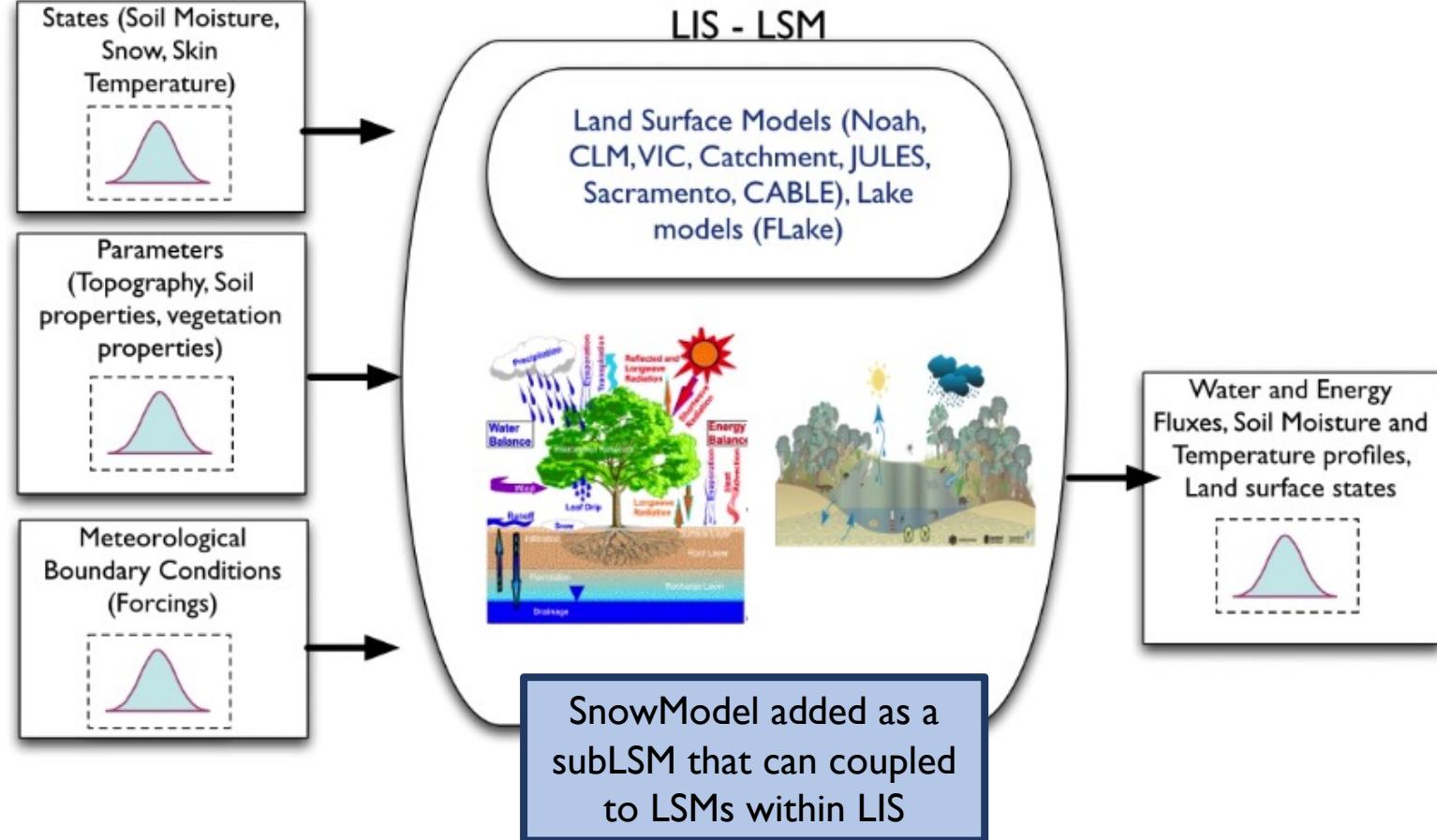
To support the NASA SnowEx Alaska campaign, we designed a model intercomparison effort designed to:

- understand where and when models agree/disagree
- determine where observations are needed to constrain model simulations
- test assimilation of observations collected during the campaign
- build a virtual field campaign



# Model setup

- Simulations run using the NASA Land Information System (LIS)
- 100 m spatial resolution
- Meteorological data from 4 km WRF simulation
- Daily output of SWE and snow depth for water years 2004-2015
- Three models:
  - NoahMP version 4.0.1
  - SnowModel
  - NoahMP+SnowModel coupled

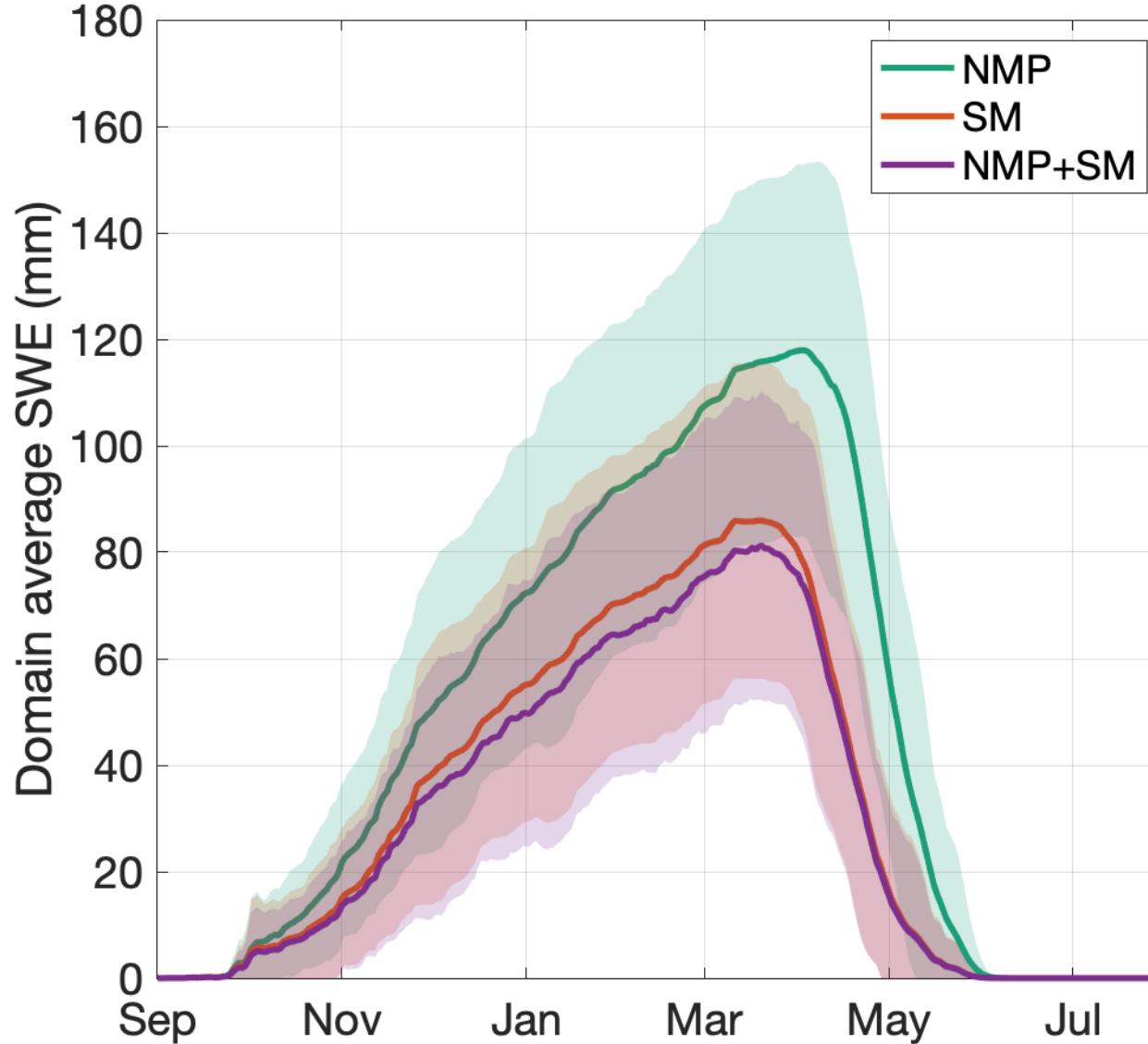


# Water Year 2004-2015

## average SWE

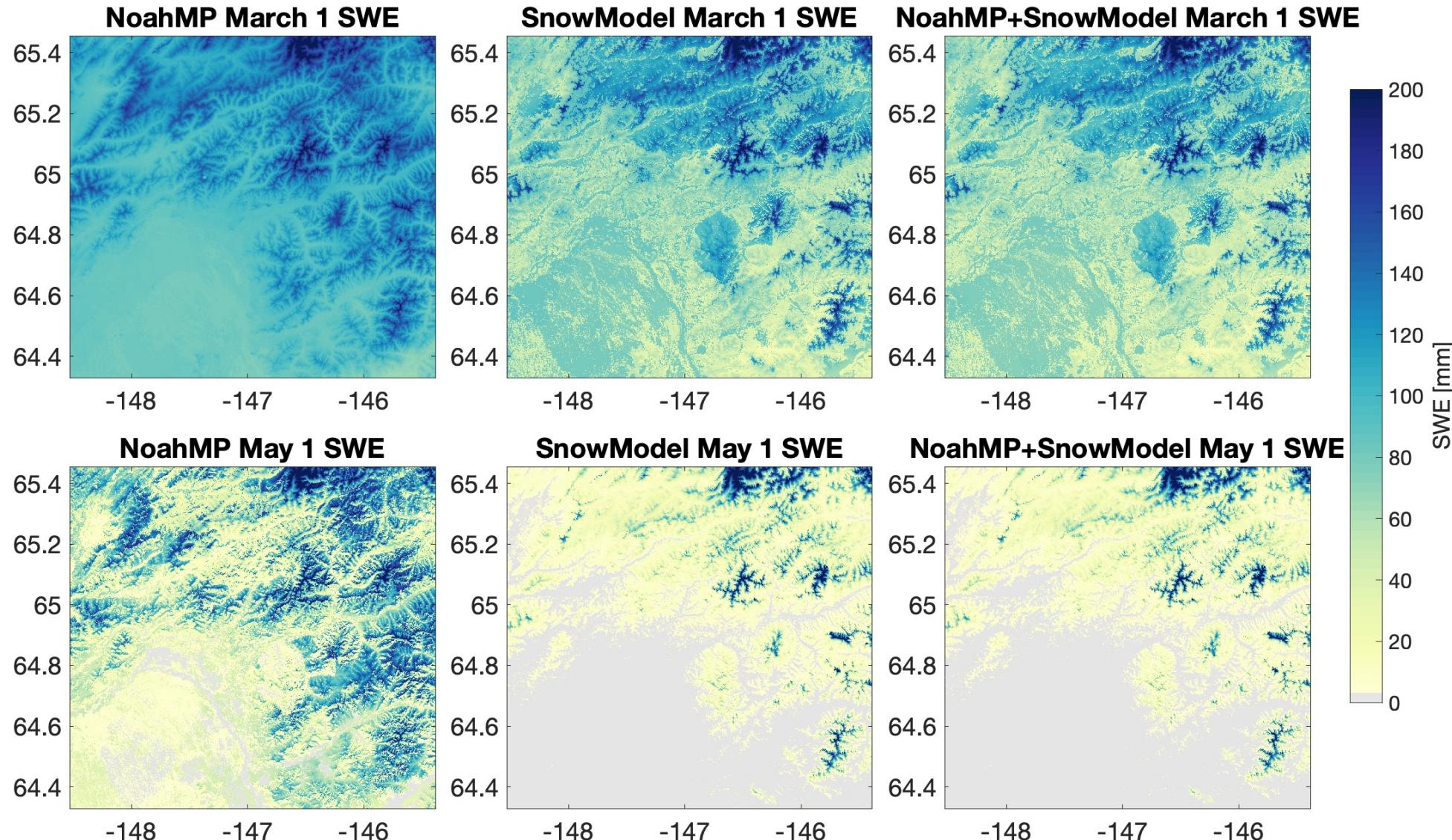
Solid line indicates the 12-year average from each model and the shading is +/- one standard deviation

- **NoahMP** begins to melt latest, though all three have similar snow off dates (~June 1<sup>st</sup>)
- **NoahMP+SnowModel** with less SWE than **SnowModel**
- **NoahMP** peak SWE ~37% larger than the other models



# Spatial maps of average SWE conditions on March 1 (top) and May 1 (bottom)

Before melt begins, **SnowModel** and **NoahMP+SnowModel** have less snow in lower elevations. **NoahMP** snow disappearance is later than **SnowModel** or **NoahMP+SnowModel**





# Integrating modeling efforts with SnowEx field campaign

- Assimilation experiments will be performed once 2023 spring field data are available
- A virtual field campaign would tie together modeling and data collection efforts
  - Near real time modeling over Fairbanks and North Slope domains
  - Share preliminary snow depth measurements in real time
  - Open science concepts with Jupyter Notebooks for evaluating model simulations
  - Online platform would allow anyone to upload field data for comparison against models

# Earth Information System efforts open and accessible science for improving understanding of the earth system



EIS is a NASA-wide effort that **integrates NASA's Earth Science observations and modeling capabilities** to produce new science and support decision making.

- Synthesize information about the water cycle by integrating available **remote sensing data** with advanced **models and data fusion tools**
- Provide an **open science environment** for addressing water security challenges facing the society
- Work with relevant **stakeholders** to provide **actionable information** about freshwater availability, quality, variability, and extremes

See <https://eis.mysmce.com/> for more information!

The screenshot shows a Jupyter Notebook interface with the following content:

## Evolution of the Floods

### Heavy Snow Blankets the Midwest Followed by Rapid Melt

From January through March, snow piled up across the Midwest with snow depths were reported at over 50" in some areas. Winter Storm Ulmer then brought warm, moisture-laden air and, with it, more precipitation. Rain-on-snow events combined with the transition from near record-low temperatures to near record-high temperatures between mid-February and mid-March resulted in rapid snow melt across the Missouri River Basin.

By assimilating AMSR2- and SNODAS-derived snow depth data over the Missouri River Basin the model accurately captured the heavy snow and rapid melt events as seen in the figures below.

```
[5]: #####
#      Calculate and plot snow depth timeseries      #
#      with climatology and anomaly                  #
#####

# calculate area average over AOI for SnowDepth_tavg
# mean_snowdepth_df = calc_area_avg(da_combined_sf_ds['SnowDepth_tavg'], mo_rb_gdf).to_dataframe()

# calculate daily climatology and anomalies
# mean_snowdepth_df = calc_daily_clim_anom_ts(mean_snowdepth_df, 'SnowDepth_tavg')

# read staged data from csv
mean_snowdepth_df = pd.read_csv('../data/staged/mo_rb_mean_snowdepth_df.csv', parse_dates=True, index_col='time')

# plot timeseries with climatology and anomaly
mean_snowdepth_ts_plot = plot_daily_timeseries(mean_snowdepth_df, 'SnowDepth_tavg', 'Snow Depth', 'm')\
    .opts(xlim=wy2019_xlim, title='Snow Depth Mean - Missouri River Basin')

#####
#      Calculate and map snow depth anomalies      #
#####

# set our before/after dates
before_date = '2019-03-10'
after_date = '2019-03-29'

snd_plot_title = 'Snow Depth Standardized Anomaly'

# calculate daily snow depth anomalies
snowdepth_anom_ds = calc_std_anomaly(da_combined_sf_ds, 'SnowDepth_tavg')

# create anomaly map plots
```

sy Mem: 1.74 / 4.00 GB Saving completed Mode: Command ↵ Ln 1, Col 1 Midwest\_Flood\_2019.ipynb

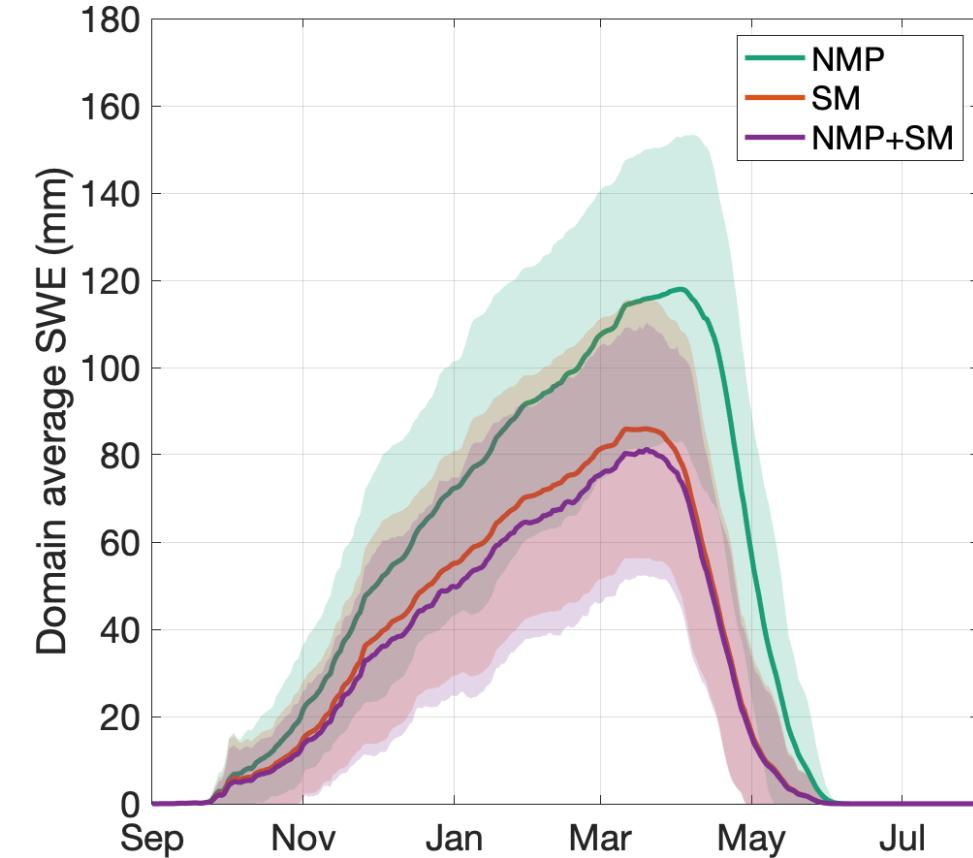
# Open science tools

- **Development of Jupyter Notebooks** for case studies allows scientific users to interact with the data and perform analyses
- Open science encourages more community engagement
- EIS data shared at **SnowEx Hackweek** modeling tutorial

Hackweek tutorials available here:  
<https://snowex.hackweek.io/intro.html>

# Summary

- Model intercomparison efforts show:
  - **NoahMP** may have snow persist too long into the spring
  - **NoahMP+SnowModel** coupling reduces the late spring melt
  - **SnowModel** soon to be available in public LIS code
- A virtual field campaign could bring together modeling and field efforts, though framework still needs to be built
- Efforts like EIS and SnowEx are important for encouraging open science and community engagement



# Thank you!

If you have any questions,  
please reach out!

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Modeling &  
Assimilation

